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ABSTRACT

The effectiveness of an automated free-play television game as a means for measuring normal and language impaired children's preferential selection of closely regulated sound values was studied. The subjects were 24 preschool children (18 with normal language function and 6 with language disabilities) from four through six years of age. The instrument system allowed four different pairs of loudness combinations to be presented so that the subjects' response records would indicate which loudness level in each pair they preferred to listen to. All children were tested in four separate sessions on four successive days. Results of the data analysis show: (1) the children showed significantly different preferences for the Optimal sound level in each of the four conditions, which indicated a relatively high degree of precision as the loudness levels differed by only about 10dB; (2) the language-impaired children were not significantly different from the normals in their preference for the optimal loudness; (3) the language impaired children were significantly less attentive to the sight and sound stimuli than were the normals, and made significantly higher response durations at the higher loudness levels; and (4) the normal children sought the stimulus feedbacks in larger, more inclusive informational units than did the language impaired children. (DB)

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Preschool Children's Self-measurement of Listening Discrimination of Four Loudness Levels of Natural Sounds with an Automated Videotape Free-play Game

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Considerable progress has been made in recent years in developing systematic methods for evaluating various aspects of children's auditory acuity and linguistic performance. But in at least one important area, developments have been slow and uncertain. Very little is known about processes of complex auditory perception and receptive language development in young children. Furthermore, there is a lack of reliable methods for studying children's subjective listening experience at various stages of psychological and linguistic growth. The absence of established, systematic methods imposes a severe restriction on the refinement of new knowledge about basic processes of language development in normal children. It also impedes clinical evaluation of subjective listening experience in young children with known or suspected language impairments.

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Professor Claude Hayes, Department of Communicative Disorders, University of Wisconsin, Mr. Robert Putzer, and Miss Patricia Hooper made major contributions to the completion of this study.

While information and techniques in these areas are now slight, the incentive to gain new knowledge and develop reliable investigative techniques is substantial. The burgeoning of powerful new concepts about the development of complex language processes in infancy and early childhood stresses the importance of the child's subjective listening experience -- how things sound to him as a form of psychological reality, above and beyond the enumeration of acoustical properties that constitute auditory stimuli. Psychologists suggest that the real work of language development consists of the child's gradual accumulation of integrative strategies with which he can code and make sense out of a bewilderingly intricate stream of auditory inputs. But for lack of suitable research methods, it is difficult to determine what use children make of their auditory and linguistic listening experience in the course of normal development. It is especially hard to estimate how development is affected when listening capability is inhibited by a loss of auditory acuity or other forms of input disability.

In the course of research on these general issues, our laboratory has sought to develop procedures with which to make highly systematic measurements of young children's voluntary listening to auditory programs whose stimulus properties could be described and manipulated with a relatively high degree of precision. Experiments reported elsewhere describe studies that have measured normal infants' selective, preferential responding to listen to such complex language dimensions as the identity of the speaker, voice intonation, and message redundancy. Those procedures employ an automated, free-play toy that attaches to the side of an infant's crib right in his own home (Friedlander, 1968).

The experiment reported here describes a procedure in which preschool children, as an adjunct to their regular school program, play with a similar automated system which lets them watch and listen to video taped selections of regular network television programs. The purpose of this study was to test the effectiveness of this free-play game as a means for measuring normal and language impaired children's preferential selection of closely regulated loudness levels of the video sound track.

Loudness was selected as the experimental variable in this study for two reasons. First, loudness is perhaps the primary dimension of any listening experience. Second, loudness is the experimental variable most easily controlled and specified. In launching what was anticipated to be

a long term research program directed toward the evaluation of many acoustical and linguistic variables in children's auditory and language perception, it seems sensible to start the work with a variable with which it was relatively easy to be exact.

METHOD

This report does not include a detailed description of all the fine points of method, experimental design, and procedure that were included in the planning and execution of the basic experimental paradigm. A more extended discussion of the method may be found in the publication version of this report.

Subjects

The subjects in the study were twenty-four children in the laboratory preschool of the Department of Home Management and Family Living and the Department of Communicative Disorders at the University of Wisconsin. This preschool is distinctive in that it includes a sub-population of children with known and suspected language impairments. The language impaired children are integrated into the regular preschool program on an equal footing with "normal" members of each class section. These children receive a special therapy program in addition to the regular activities of the preschool. Eighteen children in this experiment were drawn from the population deemed normal with respect to language function and six were from those with presumed language disabilities.

The eighteen normal children ranged in age from four years five months to six years three months (mean, four years eight months). There was an even number of boys and girls. Formal psychometric data on these children were not available, but they were deemed to be in the high normal and low superior range of intellectual functioning. The age range of the language impaired children was from four years seven months to six years seven months (mean, four years eleven months). The language impaired group included four boys and two girls. Five children in the language group had been tested with the Arthur adaptation of the Leiter International Performance Scale. One had a Leiter IQ of eighty-eight, one had a Leiter IQ of 123, and three others had Leiter IQs very close to 100. A Binet IQ of 70 was recorded for the sixth child, but this low score was suspected to have been related in part to the delay of his expressive speech and language development.

The lack of formal IQ data for the normal children, and the uncertain significance of the psychometric scores for the language impaired children make it speculative to attempt to determine to what extent real differences in intellectual capability actually existed between the two groups.

The six children with known or suspected language disabilities did not represent a single diagnostic category. All of them were described as manifesting mild to severe delayed speech development. Neurological involvement was suspected in three cases. Disabilities of visual perception were cited in two cases. Four of the six children displayed disabilities of motor performance in the form of generalized clumsiness that was deemed inappropriate for their age.

Comprehensive audiological test data were quite complete in some cases but could not be obtained for all. However, all six children were thought to be within normal limits of hearing acuity in the range of speech frequencies. The children had been recommended for the special preschool program because their language impairments, diffuse as they were, interfered significantly with the normal progress of their growth and development at home and in school.

Instrumentation

The experiment was conducted with a PLAYTEST-Video/Audio Evaluation System 69C, as shown in Figure 1.

(Figure 1 is a color photo of a child seated before the PLAYTEST system. It is not available for mimeo distribution.)

The major components of this system are the PLAYTEST System control elements, a video tape recorder and monitor, and a two-channel amplifier-attenuator which provides two independent levels of amplification for the video sound track. The child in this picture is holding a two-choice switch which turns on the video picture and one or the other level of the amplified sound track, depending upon the direction in which the child operates the switch.

An automatic response recorder registers the frequency and duration of all responses in each position. This response record provides the numerical basis for determining each child's preference for listening to one sound level or the other. A network of electrical circuits in the PLAYTEST Control regulates the system to protect the data record from experimental artifacts such as position preference and perseverative

responding. Time limitations prevent a detailed description of these aspects of the instrumentation.

In this picture the video tape recorder is at the right, the amplifier-attenuator is in the center, above the child's head, and the PLAYTEST Control with Response Recorder is at the left. In regular use all these components are enclosed in a cabinet and the child sees only the response switch and the television screen. In this experiment all sound displays were played through a loudspeaker. In some studies the audio feedback is played through an induction loop mounted in the rug on which the children sit, to be picked up by the telephone coil in the children's hearing aids.

(Figure 2 about here)

Figure 2 shows a function diagram of the PLAYTEST System. The publication report of this experiment, of which this paper is a condensation, gives a more detailed description of the components of the instrument system.

Sessions were conducted in a small room without acoustical shielding near the preschool playrooms. The ambient noise level was 60dB SPL on the linear scale of a B & K T pe 2203 Sound Level Meter, calibrated with Pistonphone model 4220. The video sound track was passed through the two-channel amplifier-attenuator in four different combinations. In these combinations one channel was always fixed at an arbitrarily chosen level of 78-80 dB, and this level was designated a Optimal. The other channel could be set to the same Optimal level, or to one of three other arbitrarily selected levels. These were: Detection Threshold level, at which the sound track was immeasurably discriminable above ambient noise; a 68-70 dB level, termed Sub-optimal; and a 90-92 dB level, termed Hyper-optimal.

The purpose of the instrument system in the experiment was to present the subjects with four different pairs of loudness combinations so their response records would indicate which loudness level in each pair they preferred to listen to.

The stimulus materials used throughout the study consisted of selections edited from network broadcasts of the Captain Kangaroo program. The normal soundtrack accompanying the video selections was processed through a Shure Level-loc at every stage of editing to minimize dynamic range.

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Procedure

Following an initial familiarization procedure, all children in the experiment were tested in four separate sessions. These sessions were arranged so that each child was tested once with each of the four pairs of loudness levels. Each child was tested individually on four successive days. The Captain Kangaroo program was different for each day to avoid response decrement due to boredom, and all four programs were edited to have equal interest value. Test sessions were eight minutes long on the first day and seven minutes long thereafter.

Test sessions followed a standard procedure. Once the children were brought to the experimental room their participation was entirely voluntary. The children were free to leave the room at any time. In the ninety-six sessions that comprised the study, children left before their time was up on only three occasions.

RESULTS

The data record for each session consisted of the total number of responses and the total duration of these responses in seconds for each of the two loudness levels. This record made it possible to determine on a statistical basis which of the two loudness levels of the sound track the children preferred to listen to.

The objective of the data analysis was to answer two fundamental questions. First, did the children demonstrate significant differences in their selective response performance with different loudness levels of the video sound track? Second, were there significant differences in response performance between the normal and the language impaired children?

The answers to both questions were clearly positive.

(Figure 3 about here)

This figure demonstrates the clear pattern of selective responding for the entire group including both the normal and the hearing impaired children.

The four columns on this chart represent the four combinations of paired loudness levels. The height of each column indicates the mean percent of selection of the Optimal loudness level for each pair. The first column shows the sessions in which the children could choose be-

tween the Optimal loudness at 78-80 dB and the Detection Threshold level, which was immeasurably discriminable above ambient noise of 60 dB. As shown in the graph, the mean of response durations was 79.7 % of the total responses for the Optimal and 20.3% for the Detection Threshold level. In the second condition, in column two, the mean of total response durations was 75% for the Optimal level and 25% for the Sub-optimal loudness at 68-70 dB.

The children's preference for the louder Optimal level and their rejection of the lower loudness levels in these two conditions is, of course, overwhelmingly significant--just as might be expected.

Column three demonstrates an essential methodological point. In this condition both positions of the children's selector switch gave them the Optimal loudness soundtrack. The obvious prediction was that the children's selective responses would be evenly divided between the two options—and this expectation was clearly supported by the data. For one channel the mean of response durations was 49.04%, and for the other the mean was 50.96%--an infinitesimal difference. It is hard to imagine a more satisfactory confirmation of the null-hypothesis. This finding gives a powerful underlining to the listening response selectivity the children showed in the other conditions where there was a real choice, inasmuch as their performance was almost exactly on the 50-50 line in the condition which gave them no difference in loudness on which a selective preference might be based.

The fourth column represents the choice between the Optimal loudness level and the Hyper-optimal level at 90-92 dB. The children preferred the Optimal level, as indicated by their mean response duration of 62.4%, compared to 37.6% for the Hyper-optimal level. This difference was significant, though not as decisively as when the choice was between the Optimal loudness level and levels at which the sound track was too soft for satisfactory listening. Time does not permit an extended analysis of the children's performance in sessions in which the comparison was between the Optimal loudness level and the level that was too loud for comfortable listening. It is sufficient to note here that some of the children appeared to take a sadistic pleasure in making the adult research assistant sit quietly while the television set blared away. She was not free to tell them to "turn that damned thing softer," and they seemed to know it, and enjoy her discomfort.

To summarize the major finding indicated in this figure, the children showed significantly different preferences for the Optimal sound level in each of the four conditions, and these differences were significant beyond the .01 level by analysis of variance F-test of the total data array and by t-test of subordinate pairwise comparisons.

In considering the audiological significance of these statistical findings, it is important to note that the four loudness levels in the experiment differed from each other by only about 10 dB from condition to condition. The children's significant selectivity between these narrow differences may be looked upon as a relatively high degree of precision, considering the entirely voluntary and spontaneous nature of their participation in the test procedure.

(Figure 4 about here)

This figure shows the same data as the preceding one, except that the records of the normal and the hearing impaired sub-groups are shown separately--means for the normal children are represented by the solid line, those for the language-impaired children with the broken line. The importance of these data lie in the fact that the language-impaired children were not significantly different from the normal children in their preference for the optimal loudness. The language-impaired children were slightly less precise in their selection, but this was only a trend, not a significant effect. The procedure was essentially as effective in measuring the language impaired children's selective preference of loudness levels as it was for the normal children.

(I would like to note here parenthetically that only last week we received a further confirmation of this technique's capability for detecting very clear differences in loudness preference by much more severely impaired preschool children. An affiliate of our research program at The Rehabilitation Center, in Evansville, Indiana, conducted by Spiro Mitsos, Marion Morgan, and David Whitten, is carrying out very systematic studies with a group of severe hearing loss rubella babies who are now at preschool age. One recent run of data showed unambiguous preferential listening between Captain Kangaroo sound tracks at 65 and 85 dB. These data are to be reported elsewhere.)

Returning to the main experiment, figures 5 and 6 show that the normal and hearing impaired children were very different in other aspects of their

selective listening performance.

(Figure 5)

Figure 5 represents the mean percent of total listening time for each group in each loudness level comparison. This figure simply tells how much time the children spent watching and listening to the television program as a percentage of the total time available to them. The difference between the groups is very conspicuous, and it was highly significant. In each condition means for the normal children's operating time on the PLAYTEST were more than 85% of the available time, and individual records in excess of 90% were not uncommon. The mean total response time across conditions for the language impaired children was 79%. The essential information here is that the language impaired children were significantly less attentive to the available sight and sound stimuli than were the normal children. They also made significantly higher response durations at the higher loudness levels.

What this finding may signify in terms of subjective listening processes is a question that can be answered only with additional data and further analytic interpretation. Perhaps the first question that requires examination is whether evidence for reduced attention in the language impaired children is a cause or an effect.

(Figure 6)

This final figure portrays another indication of differential performance between the normal and the language impaired children. The measure shown here is the mean duration per response for listening responses at the Optimal level. This datum is derived simply by taking the total seconds of response time and dividing by the total nomber of separate responses.

The mean across conditions was 8.4 seconds per average response for the normal children, and 5.6 seconds for the language impaired. This difference, which was significant at the .01 level by analysis of variance, suggests that the normal children sought the stimulus feedbacks in larger, more inclusive informational units than did the language impaired children. That interpretation must be viewed as tentative, however, partly because it is attractive and therefore necessarily suspect, and partly because it must be allowed that this type of difference may be as much due to a difference in response processes as to input or integrative processes.

But whatever the reason for the difference, the fact remains that the difference is real and very noticable. At the outset of this line of research it is less important to seek an explanation for the difference than it is to develop ways for elucidating how normal and language disabled children may differ in their ways of regulating informational inputs which they can operate under their own control.

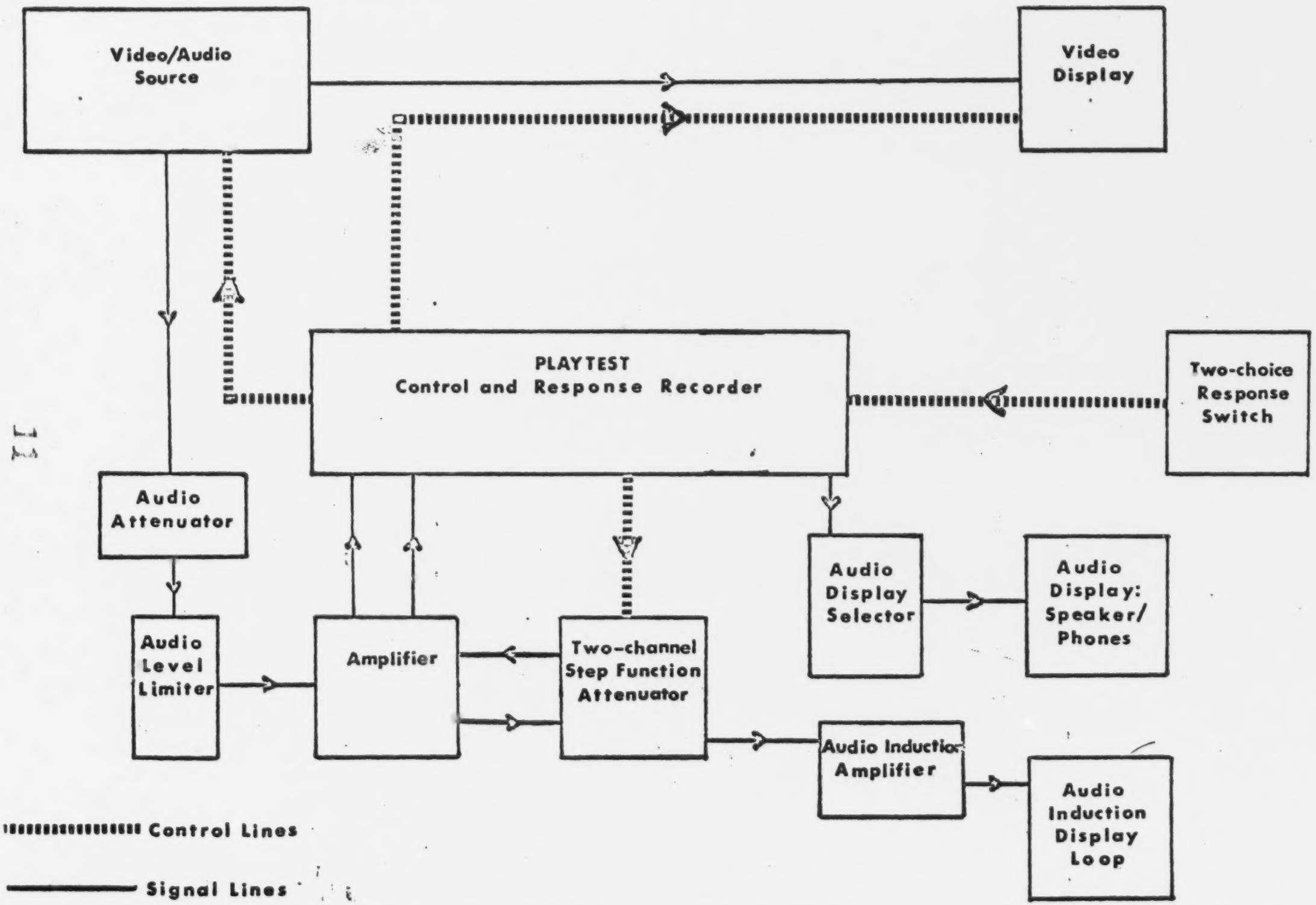
A quick summary of this study takes us back to the purpose that prompted it. We sought to test the effectiveness of an automated free-play television game as a means for measuring normal and language impaired children's preferential selection of closely regulated sound values. To carry out the test we implemented a carefully designed formal experiment to determine whether normal and language impaired preschool children would show consistent differences in their patterns of performance.

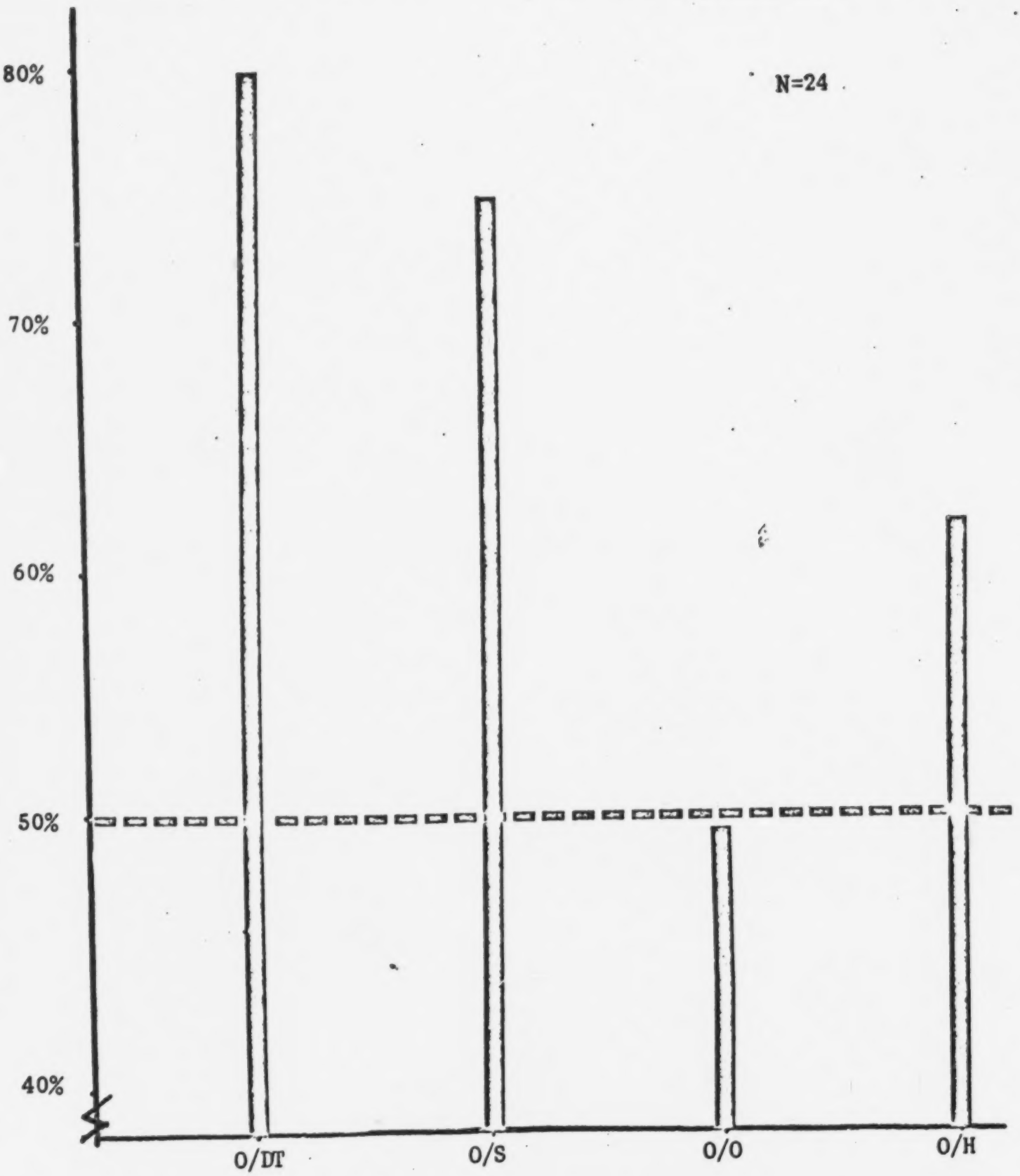
Statistical analysis of the children's listening response performance gave positive answers to both questions. The children did show significant preferences for optimal loudness when the optimal condition was paired with soundtracks that were unpleasantly loud or soft, and they did so in terms of response patterns that were clearly different for the normal and the language impaired.

One swallow doesn't make a summer, and one apparently successful experiment doesn't build an experimental or a clinical program. But the results of this study suggest that the automated television game is essentially sound as a method for evaluating children's preferences among auditory inputs that consist of reasonable approximations of natural sounds in the natural environment. These results, and the findings of related experiments already completed and now in progress, suggest that this method can successfully be applied to the challenging task of learning more than is presently known about the subjective listening experiences that lie at the foundation of language development. It will be the task of further experimental work to determine just how far this method can be exploited in examining major issues of language growth in normal children and clinical evaluation of those children with various linguistic disabilities.

Friedlander, B.Z. The effect of speaker identity, voice inflection, vocabulary, and message redundancy on infants' selection of vocal reinforcement. Journal of Experimental Child Psychology, 1968, 6, 443-459.

PLAYTEST
Video/Audio Listening Evaluation System 69C
Function Diagram





(O=Optimal; DT=Detection Threshold; S=Sub-optimal; H=Hyper-optimal)

paired loudness level conditions

Fig. 2 Self-selected loudness discrimination by 24 preschool children as measured by voluntary responses in an automated videotape PLAYTEST game. Each experimental condition gave the child free choice between television sound track at designated loudness levels. Each child was tested in all four conditions. Data demonstrated highly significant discrimination between loudness levels with complex natural sound and language stimulus materials. The full report describes other language and listening evaluation opportunities with this new technique.

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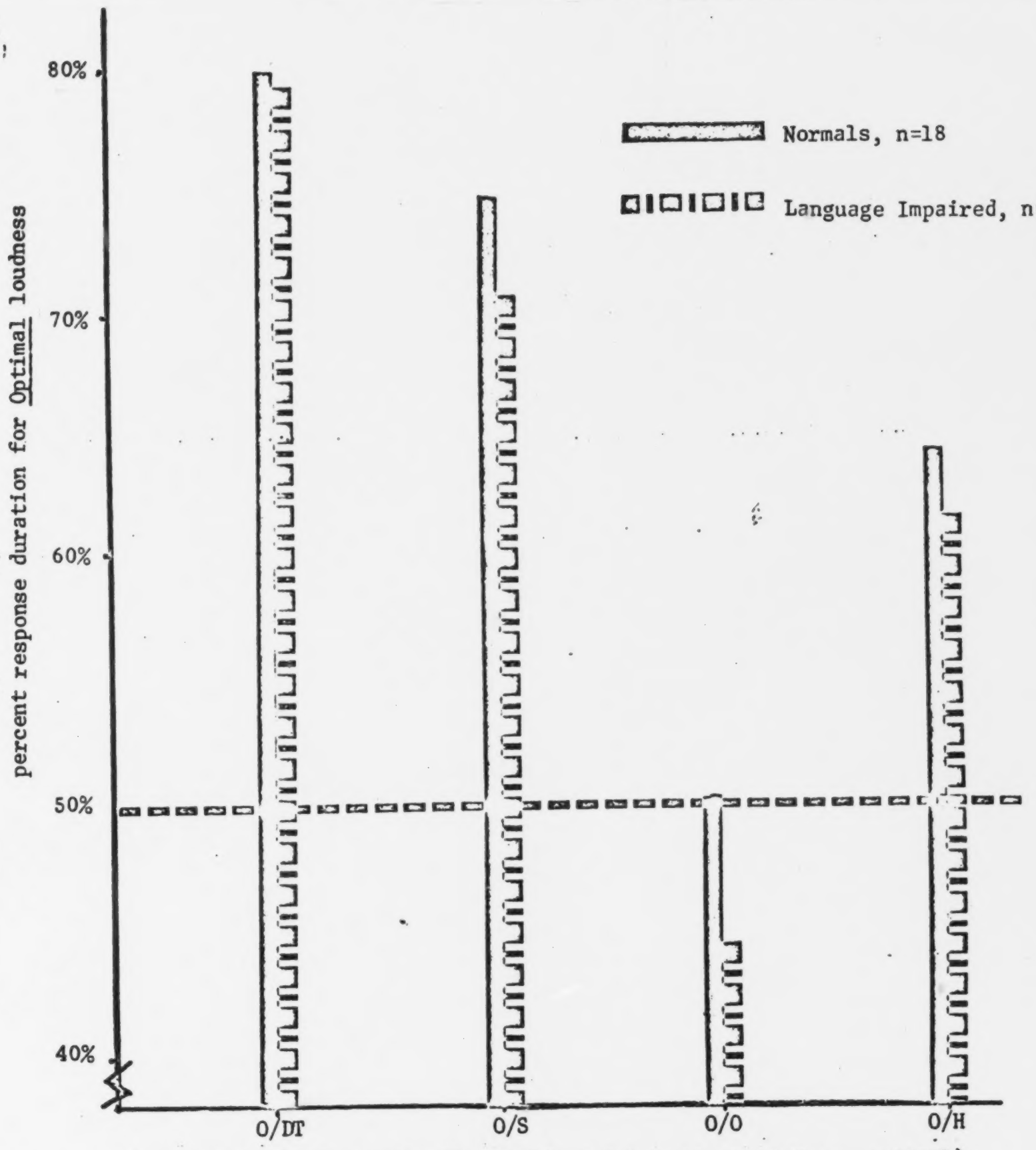

Fig.3 Means of self-selected loudness preferences seen as virtually identical for normal and language impaired preschool children.

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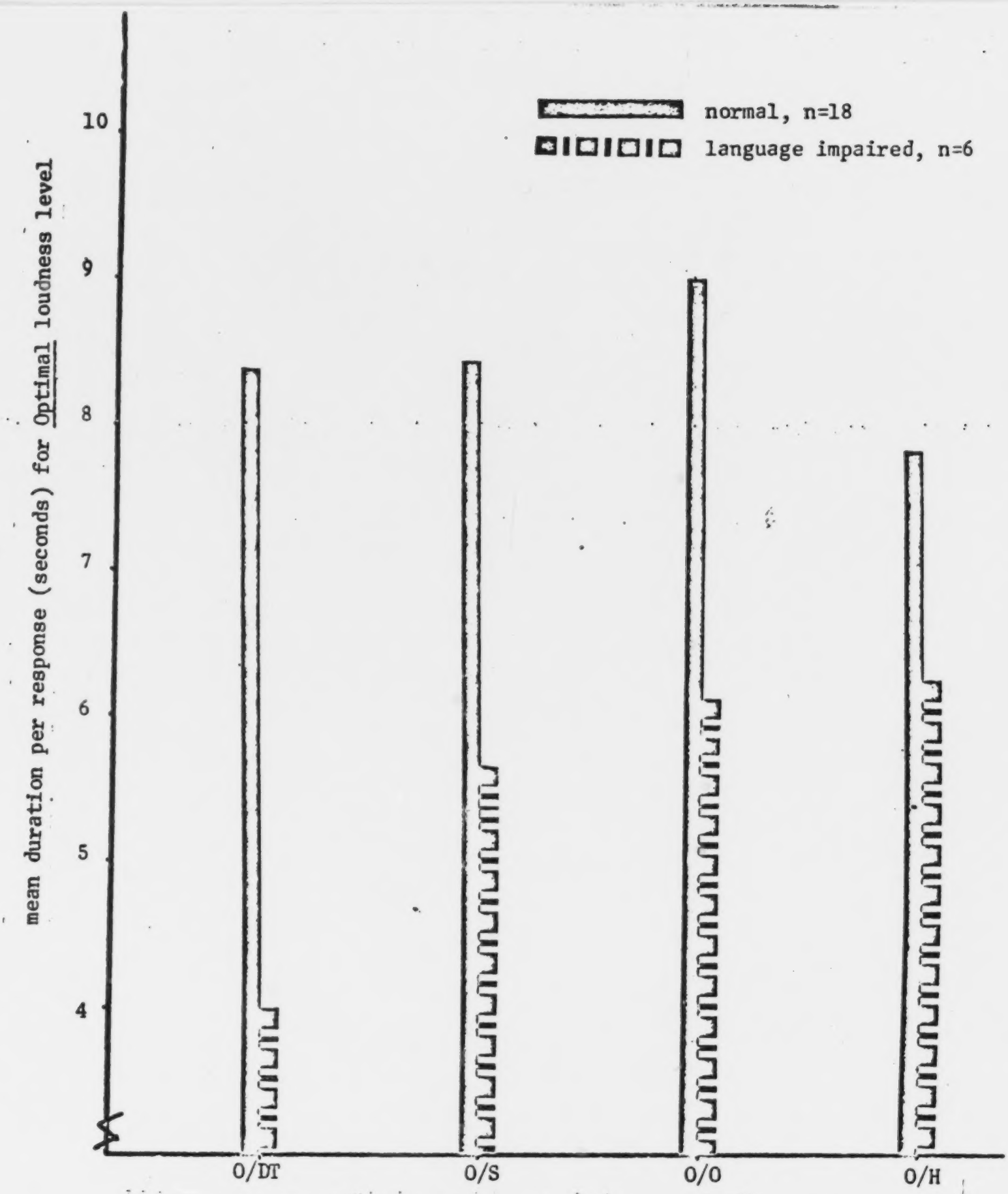

Fig. 4 Language impaired children's mean duration per response for Optimal level feedback seen as significantly lower than normal children's response durations in all conditions.

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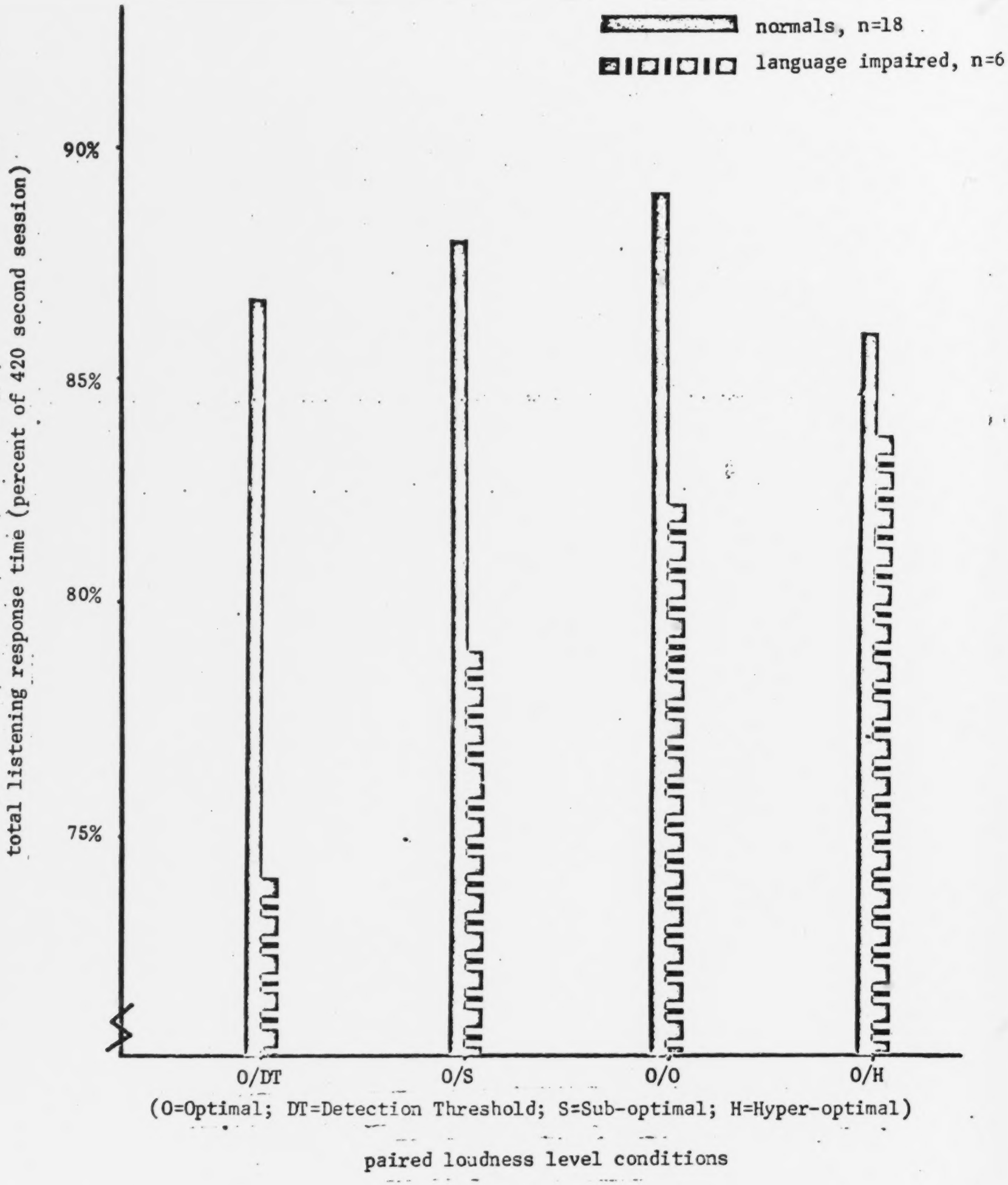

Fig. 5 Total listening response time by language impaired preschool group seen as significantly lower than comparable listening response time by normal group. Normal children's listening response time was equivalent for all loudness conditions. Language impaired response data show a significant increase at higher loudness levels.

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